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Maine Agricultural Experiment Station

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POTATO LEAFROLL

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BULLETIN 297

POTATO LEAFROLL.[1]

Donald Folsom

SUMMARY

(1) Leafroll is a potato disease recently recognized in this country. It is already very prevalent in some other states and is increasing in Maine.

(2) It is a cause of any or all of certain characteristic changes in the plant, namely, rolling, rigidity, and discoloration of the leaves, dwarfing of the plant, net-necrosis of the tubers, and great reduction of the yield. Net-necrosis in turn may cause spindling-sprout and complete absence of salable tubers.

(3) The cause of leafroll is in the juice of the plant and therefore is transmitted in the tubers and can not be reached by applications upon the outside of the plant or tubers.

(4) Leafroll is infectious. It can be transmitted from one plant to another by plant-lice, but by no other means tested thoroughly so far, except by grafting.

(5) Leafroll has been controlled in northeastern Maine by tuber selection and roguing, but where plant-lice are more abundant or leafroll more prevalent it may be necessary to use additional methods including an isolated seed-plot and a spray against plant-lice.

Introduction

Late blight[2] and the rot that it produces probably cause potato growers of Maine more loss than any other disease, especially in those seasons favorable to it and in fields where good spraying is not employed to keep it in check. Both late blight and scab[3], another of the more important potato diseases, fluctuate greatly according to environmental conditions. Mosaic[4] is becoming one of the same important class, but is different from these other two diseases in regard to prevalence and increase. It has not been known in Maine so long, and usually if present in susceptible varieties it increases from year to year until all of a stock is affected. Leafroll is much like mosaic except that it belongs, as to importance in Maine, in a group of potato diseases with early blight, blackleg[5], Rhizoctonia disease[6], and wilt diseases and their effects upon the tubers. Leafroll, however, apparently is a comparatively new disease in this country, is increasing in prevalence and importance in Maine[7], has already become very prevalent in more southern regions, and may become as serious for some varieties and places in Maine as mosaic is. Inasmuch as mosaic and leafroll are now known to be enough alike to be spread and controlled in much the same way, it seems best to enable anyone who is interested in improving his strain of potatoes to have the best information available at present in regard to leafroll.

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[1] This bulletin is intended to make available to Maine potato growers the essential facts given in a recent paper: Leafroll, net-necrosis, and spindling-sprout of the Irish potato, in the Journal of Agricultural Research, Vol. 21, No. 1. This paper was the result of investigations conducted at first independently by the Office of Cotton, Truck, and Forage Crop Disease Investigations of the Bureau of Plant Industry and by the Department of Plant Pathology of the Maine Agricultural Experiment Station, and finally as a cooperative project. The publication in different form as a Station bulletin is not intended to indicate that one cooperating institution contributed more than the other to the results.

[2] This disease is the subject of Bulletin 169 of the Maine Agricultural Experiment Station.

Net-necrosis and spindling-sprout probably belong in the group of least important Maine potato diseases, with Phoma-rot, powdery-scab[8], silver-scurf, and internal brown spot[9]. They are considered in this bulletin because they have been proven to be some of the results of leafroll. Also, net-necrosis is somewhat important as an indicator of leafroll and as a peculiar trouble whose name and cause are often subjects of inquiry by potato growers.

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[3] This disease is the subject of Bulletin 141 of the Maine Agricultural Experiment Station.

[4] This disease is the subject of Bulletin 292 of tne Maine Agrciultural Experiment Station. It may for practical purposes be considered as including curly-dwarf.

[5] This disease is the subject of Bulletins 174 and 194 of the Maine Agricultural Experiment Station.

[6] This disease is the subject of Bulletin 230 of the Maine Agricultural Experiment Station.

[7] According to oral information from Mr. E. L. Newdick, Chief of the Bureau of Seed Improvement, State Dept. of Agriculture.

[8] This disease is the subject of Bulletin 227 of the Maine Agricultural Experiment Station.

[9] Described on p. 318 and 321 and in Fig. 48 of Bulletin 149 of the Maine Agricultural Experiment Station.

EFFECT UPON THE PLANTS AND TUBERS

The name "leafroll" suggests the most important characteristic of the disease considered here, but nevertheless it is a poor name, one that is kept because no better common name is known at present. It is a poor name because rolling of the leaves is a prominent effect or symptom of a number of other diseases. This name can not be improved easily because the cause of the disease, although understood in regard to its general nature, has not been discovered and described. "Leafroll" is better as a common name than its more exact scientific equivalents "non-parasitic transmissible leafroll" or "phloem-necrosis" and will be used throughout this bulletin as a substitute for them.

The effects or indications of the disease that are most conspicuous are rolling, rigidity, and light-green, yellowish, reddish, or purplish discoloration of the leaves, dwarfing of the plants which usually remain erect and rigid, shortness of the tuber-producing branches or stolons, reduction in the number and size of tubers, rigidity or crispness of the tubers, and net-necrosis and spindling-sprout. Some of these effects may be absent at times.

The rolling of the leaves consists of an upward curving of each leaflet with the midrib at the bottom of the spoon or trough thus formed. (See Fig. 26.) Usually the rolling appears in the lowest leaves first, at about blossoming time, followed by rolling of progressively higher leaves later in the same season until most or all are rolled.

As stated before, leafroll is not the only disease that produces rolling of the leaves. The rigidity or stiffness of the affected foliage (Figs. 29 and 30) contrasts with the drooping, wilted condition found with leaf rolling on plants affected with wilt diseases[10]. Leaf rolling on plants affected with Rhizoctonia will not be misleading if the cause of the former is disclosed by closer examination especially for the characteristic underground stem browning. Leaf rolling in connection with blackleg usually appears on the entire plant at once, accompanied by quite pronounced yellowish discoloration. Disclosure of the blackened underground stem will distinguish this disease from leafroll further. Leaf rolling resulting from excessive soil moisture resembles leafroll very closely, but appears only in sharply defined areas where the soil appears too wet. In hot, dry weather, leaves may be rolled, especially the older ones next the soil, but then limpness rather than rigidity, and rolling on the side most

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[10] In Maine usually caused by *Verticillium albo-atrum* Reinke and Berthold rather than by *Fusarium* sp.

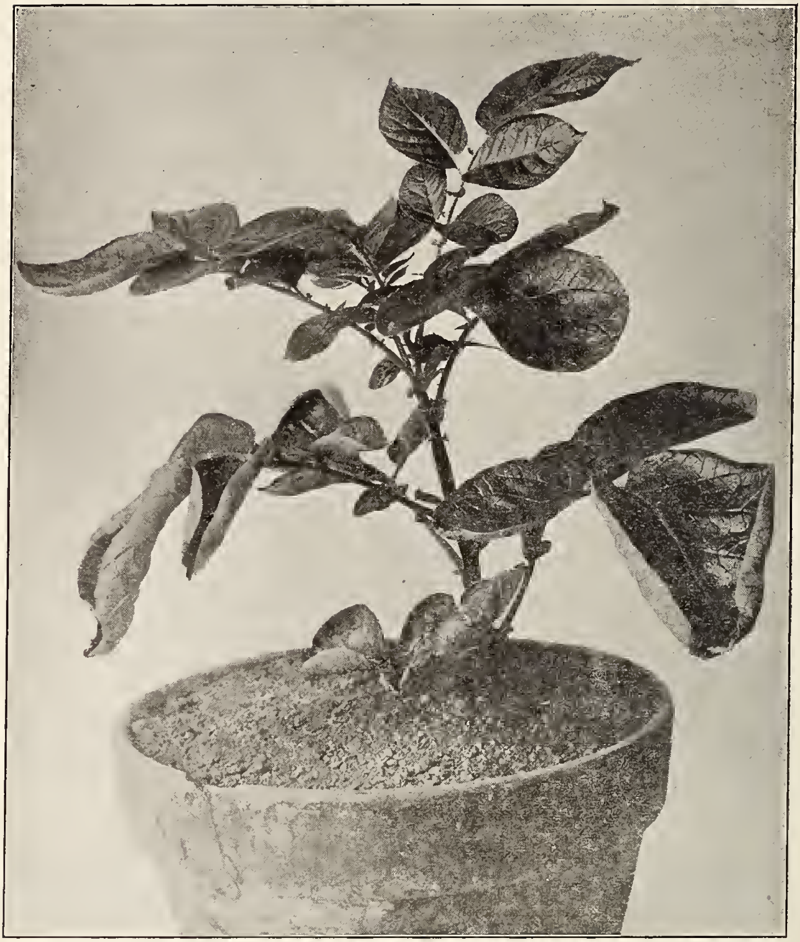

FIG. 26. Greenhouse-grown progeny of a net-necrosis tuber from Green Mountain stock that showed net-necrosis and leafroll the preceding season.

exposed to the sunlight, will indicate the cause. Occasionally leaves that are injured by insects are rolled, but here the rolling is not symmetrical as in leafroll and usually appears in only a few leaves in the top of the plant. Leafcurl or curly-dwarf is marked by a rolling downward along the midrib, instead of by a rolling upward along the sides. Finally, in this connection it may be pointed out that occasional confusion of blackleg, Rhizoctonia, and wilt hills with leafroll hills will not be of great importance to the practical grower of seed potatoes inasmuch as all should be removed in any method designed to improve seed stock.

Leafroll hills that are not dwarfed because only slightly affected are rare, but should be recognized and can be distinguished from healthy ones by the rigidity or stiffness of the foliage if the healthy hills also show rolling in the lower leaves because of age or drought. This rigidity or stiffness is apparent to the eye (Figs. 29 and 30), and when the leaves are handled it is also apparent to the touch by the leathery, brittle texture and to the ear by a peculiar rattling as the leaves strike each other. The effect upon the external appearance of the tubers and the branches producing them (Fig. 27) is of less importance than the leaf symptoms for quick identification during control operations. The effects upon the tubers in regard to size, texture, color, and sprouts may be of value in tuber-selection control measures, as will be shown more exactly later. These effects in regard to net-necrosis and spindling-sprout will now be discussed.

RELATION TO NET-NECROSIS AND SPINDLING-SPROUT

Net-necrosis is the name of a condition in which there is a net-like darkening, seen when an affected tuber is sliced along the side (Fig. 31). Slices across the tuber then disclose dark spots and streaks where the netting is cut (Fig. 32). In less severe cases the darkening may not make a complete net. Net-necrosis will be considered in this bulletin only as the kind produced by leafroll. A similar darkening has been found to be due to frost injury[11], and the darkening sometimes may be somewhat like that caused by wilt diseases.

Net-necrosis is often the cause of unusual reduction in the number and size of the sprouts, and so may be a cause of spindling-sprout (Figs. 28 and 33). This is not surprising inasmuch as the darkening results from a death of the food-transporting channels of the tuber so that the sprouts can not get enough of the materials needed for normal growth. Although net-necrosis is not the only cause of spindling-sprout[12], it is obvious that sometimes elimination of net-necrosis will eliminate or reduce spindling-sprout.

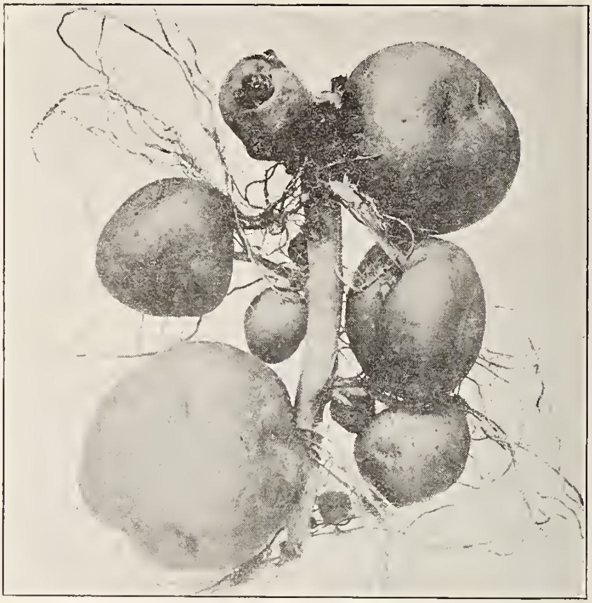

FIG. 27. Characteristic yield of leafroll plant, with small and closely set tubers. As is well known, healthy plants set most of their tubers several inches away from the stem.

Several kinds of evidence show that net-necrosis is one of the effects of leafroll. First, net-necrosis tubers produce leaf-

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[11] Jones, L. R., Miller, M., and Bailey, E. Frost necrosis of potato tubers. Wisconsin Agri. Exper. Sta. Research Bul. 46. 46 p. 12 figs. 1 pl. (col.) 1919.

[12] Stewart, F. C. and Sirrine, F. A. The spindling-sprout disease of potatoes. New York State Exper. Sta. Bul. 399:133-143. Pl. 1-3. 1915.

Coons, G. H. Michigan potato diseases. Michigan Agri. Exper. Sta. Special Bul. 85. 49 p. 41 figs. 1918. See p. 29.

Haskell, Royal J. Fusarium wilt of potato in the Hudson River valley, New York. Phytopath. 9:223-260. 1919. See Pl. 13, Fig. B.

roll plants. A number of separate lots of net-necrosis tubers have been secured in different places in Maine the past few years and have been grown at Aroostook Farm and Highmoor Farm, the experimental farms of the Maine Agricultural Experiment Station situated respectively in the northeastern and southern parts of the state. In the years from 1915 to 1919 inclusive, 30 lots of tubers were planted for net-necrosis studies, no two lots having a common origin as far as is known. Some of these lots were divided and grown on the two farms and some were grown the second season, to make the conclusions more reliable. Of the 30 lots, 26 came from about 15 different places and represented about as many different varieties, and produced leafroll plants. Two others, the first ones planted, made weak hills but the records do not indicate whether or not leafroll was present. The two remaining lots contained doubtful cases of net-necrosis and produced healthy plants, being examples of the difficulty of

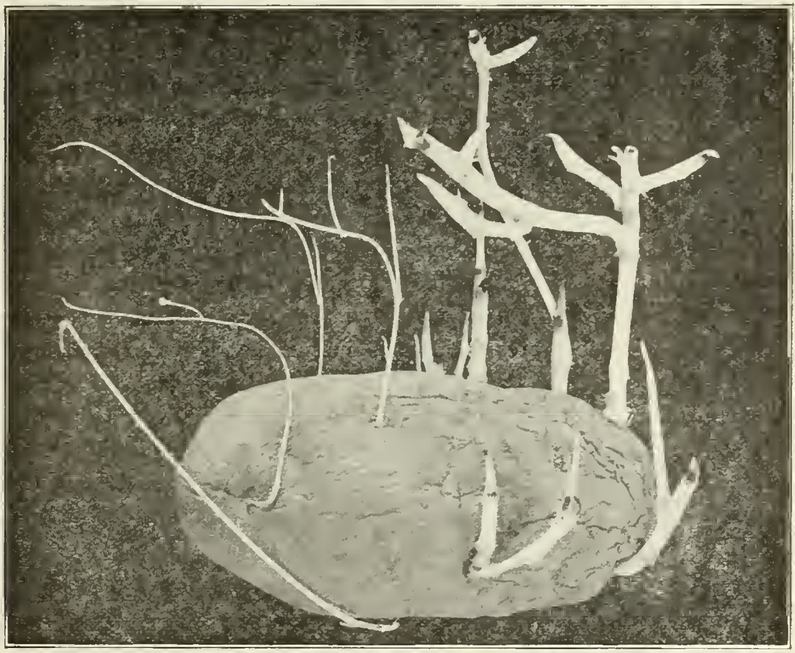

FIG. 28. Tuber with spindling-sprouts coming from the part which later was found, by cutting, to be affected with net-necrosis.

being sure of supposed mild net-necrosis. Whenever all the tubers in a lot were unquestionably or severely affected the plants produced by them were all leafroll or spindling or both. The effect of net-necrosis in four hills all progeny of the same tuber is shown in Fig. 34. In 1920, more careful observations were made in a final test of the reliability of net-necrosis as an indicator of leafroll. About 8,000 tubers were examined for net-necrosis and planted, and about 250 were considered to have net-necrosis. Of these, over 240 produced leafroll plants, some of the rest not sending sprouts above ground and others proving to be wilt tubers.

Net-necrosis is not only confined to tubers that have leafroll, except for occasional cases of confusion with other tuber-darkening troubles, but both net-necrosis and leafroll produce the same kind of internal injury, namely, a death of the food-transporting channels. Finally, net-necrosis appears only in the tubers of plants that have had a chance for leafroll to infect them, and the conditions that determine whether or not net-necrosis results as an effect of leafroll infection have been disclosed to some extent. These conditions are concerned with variety, the weight or size of the tubers, and proximity to leafroll hills. The best way known at present for the securing of net-necrosis tubers is to grow large healthy hills of the New White Hebron variety or of the Green Mountain variety next to leafroll hills in the same row, with plant-lice present to spread leafroll, and then to keep the tubers in any ordinary cold storage bin until the next spring or at least through most of the winter.

Inasmuch as it is considered that spindling-sprout may follow net-necrosis, and that the latter is in turn caused by leafroll, it is clear that the spread and control of spindling-sprout and net-necrosis will be involved in any discussion of the spread and control of leafroll. Therefore in the rest of this bulletin no mention of the two dependent diseases is needed except where they are important as effects of leafroll.

EFFECT UPON YIELD

A small yield is to be expected with leafroll present because of the dwarfing of the plants and because of the injury to the food-transporting channels that ordinarily serve for the passage of the materials needed to form starch and other substances in the tubers. Tests have shown that when the leafroll hills of a stock are grown separately, the leafroll part will yield only from 15 to 40 per cent as much as the healthy part. When leafroll hills come from net-necrosis tubers they may yield nothing. When the diseased hills are scattered among the healthy hills their poor yield may, as shown by experiments, be balanced somewhat by better yields of the healthy plants growing next to the dwarfed leafroll hills, but even then there is some reduction which is greater as the percentage of leafroll hills is greater. Moreover, in at least some places this percentage increases from year to year so that the danger and loss become steadily greater.

CAUSE OF THE DISEASE

The practical problems of leafroll can be understood better if the general nature of the cause is kept in mind. Leafroll is like potato mosaic and a number of diseases of other plants, all of which are called virus diseases. The exact cause has not been discovered, but it is known to be something in the juice of the plant. Therefore it will remain in the plant or its tubers as long as they contain juice or water, and it will spread from a diseased to a healthy plant only when some of the juice of the one in some way gets into the juice of the other. This type of disease is especially involved with the food-transporting channels, so that insects that extract their food from these channels and that pass from one plant to another are well fitted to spread it, as will be shown more fully later.

TRANSMISSION BY THE TUBERS

One strong proof that leafroll is a disease of the virus type is its transmission in tubers that usually are without any very apparent sign of it. Tubers of leafroll hills always produce similar leafroll plants except in rare cases where they are too severely affected by net-necrosis to produce more than spindling, sprawling vines. This fact does not mean that apparently healthy hills will not have leafroll progeny, for the disease often enters the plant too late in the season for it to be shown in the old leaves, but not too late for it to reach the tubers and infect them.

PROOFS OF INFECTIOUSNESS

As soon as a disease is suspected to be one of the virus type, the first step is to prove that it can be spread or transmitted from one plant to another. The most promising way is by means of grafts, where a diseased plant part and a healthy one can be joined into a single structure with the best chance for juice of one to enter the other. This was done with both tubers and leafy shoots, and leafroll was transmitted to originally healthy plants in the grafts that gave successful union.

Another kind of observation indicated that leafroll may spread from one plant to another in the field. Healthy hills at different distances from leafroll hills became diseased in more cases as they were closer to the diseased hills. They did not show this in the same season, because the disease took effect too late in the season to be apparent, but their tubers were infected and the second generation disclosed the results of too much proximity to leafroll hills the previous season. Not only did individual hills contract leafroll more often as they were closer to diseased plants, but rows of several hundred hills showed the same results from being near to diseased rows.

TRANSMISSION BY PLANT-LICE

The preceding tests showing infectiousness suggested that plant-lice (Fig. 35) might be a cause of the spread from plant to plant in the field, because results of tests so far were like those for mosaic which finally had been proved to be transmitted by plant-lice or aphids.[13] Therefore the same methods were used with leafroll that were successful with mosaic. Four types of experiments were performed, each of which proved that plant-lice could transmit or carry leafroll from one plant to another. They will be described fully because they furnish the strongest reason for the adoption of certain methods recommended to anyone desiring to eliminate leafroll.

EXPERIMENT 1. Healthy plants were grown within a few feet of leafroll plants in each of two greenhouses. Plant-lice were present in one greenhouse and were eliminated in the other by frequent tobacco fumigations. The plant-lice passed freely from the leafroll to the healthy plants in the first greenhouse. As a result a few of the healthy plants there showed some leafroll before the tubers were dug and almost half of their tubers produced leafroll plants. In contrast, the plants in the second greenhouse remained healthy and all of their tubers produced healthy plants. Apparently the disease spread only in the greenhouse containing plant-lice.

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[13] These insects are the subject of Bulletins 147, 242 and 282 of the Maine Agricultural Experiment Station.

Experiment 2. Tubers from healthy Irish Cobbler hills were split in two and the halves were planted in pots in the greenhouse. The plants were covered with insect cages, made of cloth and wire screening, in order to keep in or keep out insects. The plant growing from one half of each tuber was fed upon by plant-lice transferred to it as soon as they had been removed with a brush from a leafroll plant. The plant from the other half was not fed upon by plant-lice or was fed upon by the same kind of plant-lice from mustard plants, and in each case remained healthy and produced healthy tubers and progeny. However, the first set of plants became leafroll, some in the first generation and all in the second. Thus transferring of plant-lice by hand from leafroll plants to healthy ones was enough to carry the disease and similar transferring of plant-lice from healthy mustard plants had no injurious effects. Therefore plant-lice are carriers of leafroll only when they are carriers of juice that they have sucked from leafroll plants.

Experiment 3. Here the preceding greenhouse experiment was duplicated in the field, larger insect cages being used to cover the hills. In the greenhouse the disease could not be carried in the soil because each plant was grown in a separate pot. In the field, too, there was no chance for soil transmission because the experiment was performed upon soil that as far as was known had never supported leafroll plants and that had not given leafroll to plants grown upon it in a preceding year. Also, this soil was higher than the surrounding land, so that no water from leafroll plots drained into it, and it was cultivated with different tools from those used with leafroll plants in other plots. Seventy tubers were planted of a strain free from leafroll. The plants from two tubers were fed upon by plant-lice taken from leafroll plants and as a result showed some leafroll, in their upper leaves, before they were dug. They also produced tubers of which two-thirds produced leafroll plants. Of the rest of the plants produced by the 70 tubers, all were healthy and 49 were dug and their progeny were all healthy. Apparently plant-lice could carry leafroll under field conditions as well as in the greenhouse.

EXPERIMENT 4. In the three preceding experiments the second generation had to be grown to be completely sure of the results of the treatment given to the first generation. This was necessary because the plant-lice were introduced so late. In the fourth experiment they were introduced when the first generation of potato plants had barely begun to grow, by allowing them to feed upon the small sprouts of the seed-pieces. Half of the seed-pieces that were fed upon by plant-lice from leafroll plants became leafroll, shown by their producing leafroll hills while the untreated seed-pieces from the same tubers produced healthy plants.

To these proofs of transmission of leafroll by plant-lice there may be added those of an investigator in Holland[14], who performed experiments like the third one in the series above. with similar results. These proofs are made more convincing also by the fact that plant-lice transmit other virus diseases such as potato mosaic[15] and certain similar diseases of cucumber,[16] spinach,[17] sugar cane,[18] sweet pea,[19] and tobacco.[20] Although potato leafroll may be transmitted by plant-lice as is potato mosaic, it does not follow that it will spread in the field as rapidly as mosaic will, at least in Maine.

RELATION OF THE SPREAD OF LEAFROLL TO FACTORS OTHER THAN PLANT-LICE

Tests with flea beetles, Colorado potato beetles ("potato bugs"), and the seed-cutting knife, have not been made with leafroll but they have been made with mosaic and the resulting conclusion was that these factors are not important. Tests regarding contact and soil were not as complete with leafroll as with mosaic but with both diseases the conclusions were that these factors, also, are not important in transmission or spread Many varieties are susceptible to leafroll including some that are resistant or immune to mosaic, so that in some varieties a potato grower may have to combat leafroll and not mosaic.

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[14] Botjes, J. G. Oortwijn. De Bladrolziekte van de Aardappelplant. viii+ 136 p., 16 fig. (German summary p. 123-136). 1920.

[15] See Bulletin 292 of the Maine Agricultural Experiment Station.

[16] Doolittle, S. P. The mosaic disease of cucurbits. U. S. Dept. of Agri. Bul. 879. 69 p. 10 pl. 1920.

[17] Smith, Loren B. The life history and biology of the pink and green aphid *(Macrosiphum solanifolii* Ashmead). Virginia Truck Exper. Sta. Bul. 27:27-79. Figs. 3-11. 1919. See p. 34.

[18] Brandes, E. W. Artificial and insect transmission of sugar-cane mosaic. Jour. Agri. Research 19:131-138. 1920.

[19] Taubenhaus, J. J. The diseases of the sweet pea. Delaware Agri. Exper. Sta. Bul. 106. 93 p. 44 fig. 1914. See p. 57.

[20] Allard, H. A. The mosaic disease of tobacco. U. S. Dept. Agri. Bul. 40. 33 p. 7 pl. 1914.

Locality is the only other condition of apparent importance, and this may be somewhat involved with plant-lice. In different fields of the same locality, in different localities of the same region, and in different regions of the same country, there is not always the same abundance of plant-lice upon potatoes, and their abundance has been correlated with the spread of potato mosaic. In some conditions it seems easier to transmit mosaic than leafroll. It seems probable that in some regions, localities, and seasons, there are enough plant-lice to spread mosaic but not enough to spread leafroll, or just enough to spread mosaic considerably but leafroll very little. Thus an explanation is offered for the fact that leafroll may remain very small in amount, or even absent, in stocks in the north while increasing rapidly in parts of the same stocks taken to the south[21] where plant-lice are abundant in the winter[22] when entirely absent (except in the egg stage) in Maine. The same explanation is applicable for the greater spread in some localities and seasons in Maine than in others.

MEASURES FOR CONTROL

Although more work has been done in Maine upon the control of potato mosaic than upon the control of leafroll, the former work is of some value in regard to leafroll because of the similarity of the two diseases, both being virus or juice diseases apparently spread in the same general way. Moreover, some methods have proven more successful for leafroll than for mosaic, at least in northeastern Maine, and leafroll is still much less common and thereby easier to eradicate. Therefore it is possible to recommend certain measures that promise to be of help in eradicating or controlling leafroll.

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[21] Wortley, E. J. Potato leaf-roll: Its diagnosis and cause. Phytopath. 8:507-529. Figs. 1-16. 1918.

[22] Smith, Loren B. Op. cit., p. 53.

TUBER SELECTION

It follows from the relation between leafroll and net-necrosis (p. 41) that discarding net-necrosis tubers will reduce leafroll. It is necessary to discard the whole of any tuber that contains darkened parts. Although seed-pieces that contain the darkening produce plants that are more dwarfed than those from the other seed-pieces of the same tuber, the latter apparently healthy seed-pieces also will produce leafroll and dwarfed plants (Fig. 34).

Not all leafroll tubers will have net-necrosis, and in some varieties none will show it. Beyond discarding net-necrosis tubers, further reduction of leafroll then is possible by discarding the smallest tubers. In 1919, four partly leafroll lots were dug without any removal of leafroll hills during the summer and were planted in 1920. One of these was a Green Mountain row with 5 per cent leafroll the first season and 4 per cent the second. No unusual tuber selection was tried here. The three others were Irish Cobbler rows with all tubers weighing less than about 4 ounces discarded, a more rigorous selection than usually occurs. Two showed decreases from one season to the next in leafroll percentages, dropping from 11 to 4 and from 14 to 8. The third showed an increase from 5 to 10 because it was grown next to a wholly leafroll row during the first season. Reduction of leafroll in this way by discarding small tubers apparently is due to the small size of many tubers in leafroll hills and to the slowness of the spread of leafroll. Therefore it may not be successful in places where plant-lice are numerous enough to spread leafroll to many healthy hills that produce large tubers.

HILL SELECTION

The selection of healthy hills in a field that contains many diseased plants has been successful with mosaic only where plant-lice were entirely absent or nearly so. Hill selection has been more successful with leafroll probably because there were less leafroll plants present and because it was not spread so readily under the existing conditions. It will be more successful with leafroll as the selected hills are farther from diseased hills and as the number of plant-lice is smaller. It should not be attempted in preference to roguing except possibly when the strain is over one-fourth diseased and is better yielding than any that can be obtained free of leafroll.

REMOVAL OF DISEASED HILLS

The removal or roguing out of diseased hills has been found to be of help in reducing the percentage of mosaic or, in seasons of many plant-lice, in at least preventing much increase.[23] It has proved still more helpful in reducing leafroll. A single roguing in part of a Bliss Triumph lot in 1918 made, in 1919, the difference between 8 and 2 per cent. In 1919 it practically eliminated 5 per cent from a Green Mountain lot, and in Irish Cobbler lots it eliminated 14 per cent in a field where there were few plant-lice, reduced it from 11 to ½ per cent in a row about 3 yards from a leafroll row, and held it at 5 per cent in a row next to a leafroll row.

The removal or roguing out of leafroll hills in the preceding tests would not have been so successful in a place where plant-lice were more abundant or if done without certain precautions. Leafroll often does not appear until the plant has reached the blossoming stage. If roguing is done too early in the season some plants with the disease will not yet show the signs, and if postponed too long plant-lice will have taken the disease to healthy plants and also the dwarfed leafroll plants will be hidden by healthy plants. Incomplete removal of a hill from the soil will allow it to take root and live, especially if the seed-piece is left or if a rain occurs soon and washes the soil around the roots. It is best to remove the rogued hills from the field or plot if plant-lice are on them. These insects (Fig. 35) usually are most abundant on the lower surfaces of the leaves.

APPLICATION OF FUNGICIDES AND INSECTICIDES

The treatment of the seed and the application of spray preparations as recommended for many other potato diseases[24] could not be expected to be helpful with leafroll, the cause of which is inside the plant in the juice, except for sprays that reduce the number of plant-lice or aphids. Experiments with aphid sprays in Maine have not yet progressed far enough to justify definite recommendations about the method of spraying to be used in given conditions of leafroll percentage and aphid infestation. In Virginia, where tests have been made primarily against potato plant-lice[25] the method found to be best is one that uses three nozzles to the row, nozzles having openings of about 1/16 inch in diameter, 150 to 200 pounds pressure, and a formula as follows:

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[23] Bulletin 292 of the Maine Agricultural Experiment Station, p. 182-183.

[24] "How to Control Potato Enemies." Miscellaneous publication 535 of the Maine Agricultural Experiment Station.

Nicotine sulphate[26]	8¾ fluid ounces[27]
Fish-oil soap	5 pounds
Water	50 gallons

These tests in Virginia also showed that rather good results were obtainable with a Bordeaux-nicotine combination made by adding 8¾ fluid ounces[27] of nicotine sulphate to the completely prepared Bordeaux Mixture. It is not known yet what the effects are of using such a combination with the common Maine outfits with lower pressure or with one or two nozzles to a row.

SEED-PLOT

Elimination of leafroll and of other diseases as well, such as mosaic, blackleg, Rhizoctonia disease, and wilt, probably can be done enough better in an isolated seed-plot to justify its establishment. Tuber selection, roguing, and spraying for plant-lice can be done most thoroughly when restricted to a seed-plot, and are the best means known for eliminating leafroll. Isolation of the seed-plot from badly diseased fields will reduce the chances for plant-lice to spread leafroll to the seed-plot.

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[25] Smith, Loren B. Potato spraying experiments on the control of the pink and green aphid *(Macrosiphum solanifolii,* Ashmead). Virginia Truck Exper. Sta. Bul. 29:101-118. Fig. 18. 1919.

[26] Such as "Black-leaf 40" sold by the Kentucky Tobacco Product Company, Louisville, Kentucky.

[27] About ½ pint in standard liquid measure.

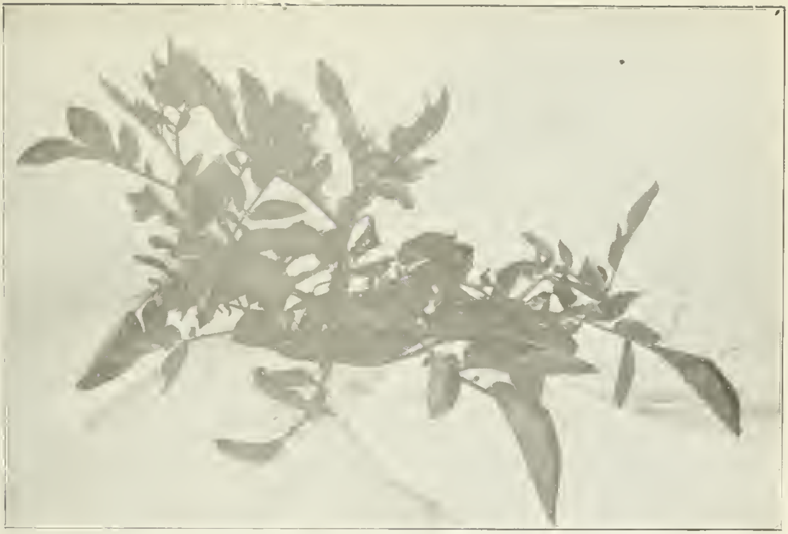

Fig. 29. Green Mountain potato plant, produced by a net-necrosis tuber and showing leafroll. For healthy plant in the same hill lot, produced by a healthy sister tuber, see Fig. 30.

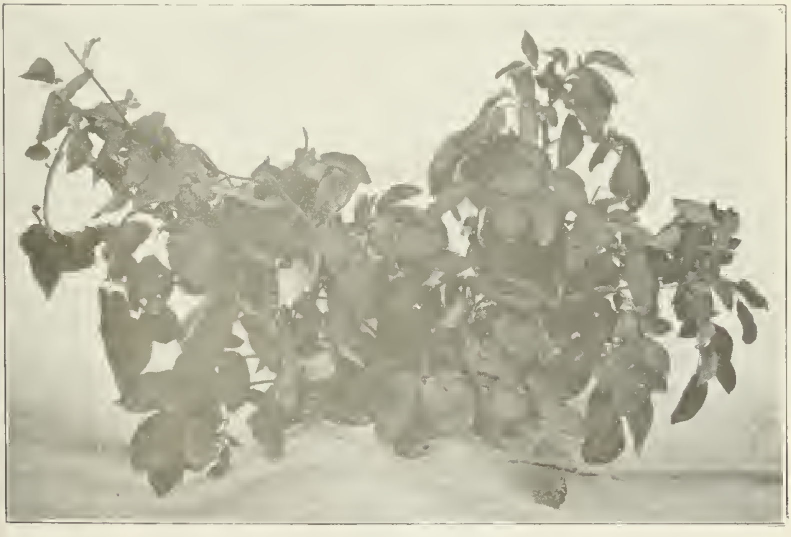

Fig. 30. Healthy control to leafroll plant shown in Fig. 29.

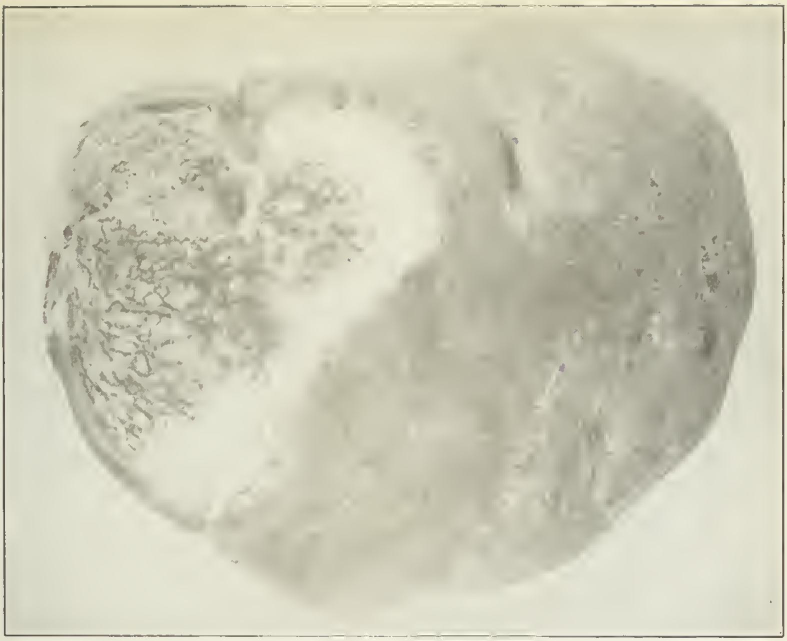

Fig. 31. Tuber with part of stem end cut away to show net-necrosis. The two deep holes are due to cutting out effects of insect injury.

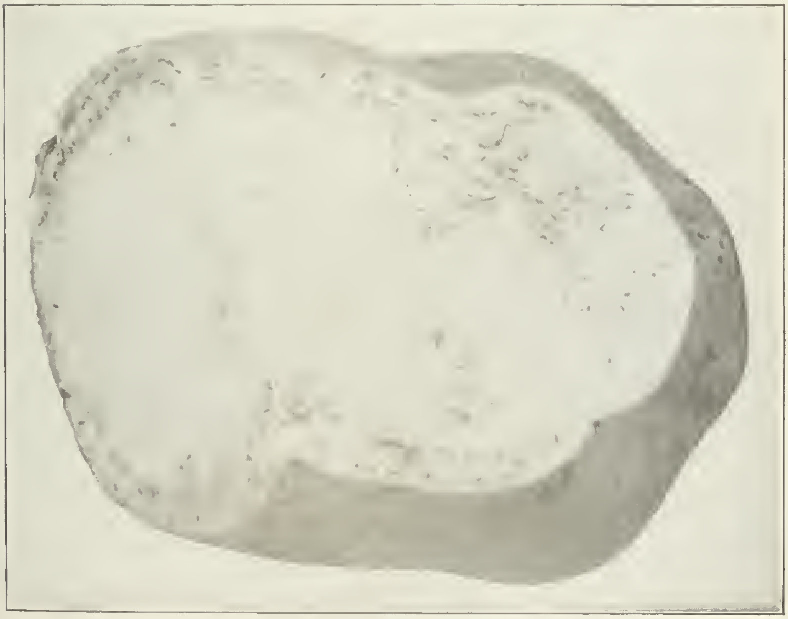

Fig. 32. Net-necrosis tuber with part of stem end and of side sliced off.

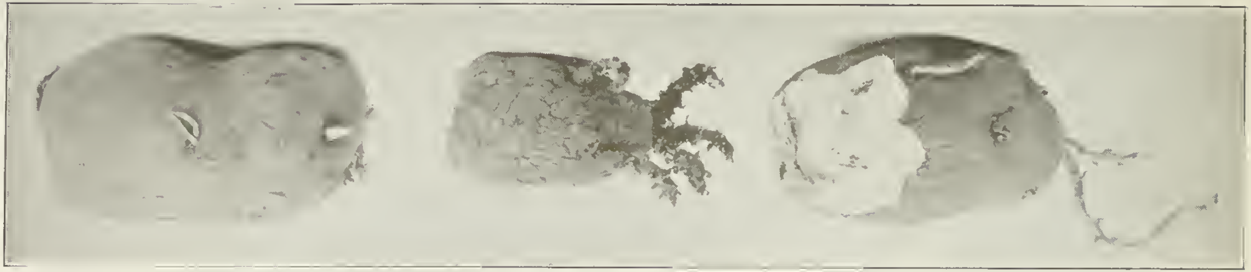

FIG. 33. Green Mountain tubers kept in the same sack in a warm room from June 1 to August 11, 1919. The middle one had no net-necrosis and is withered, soft, and bearing normal sprouts. The others had net-necrosis and are smooth, firm, and bearing spindling sprouts.

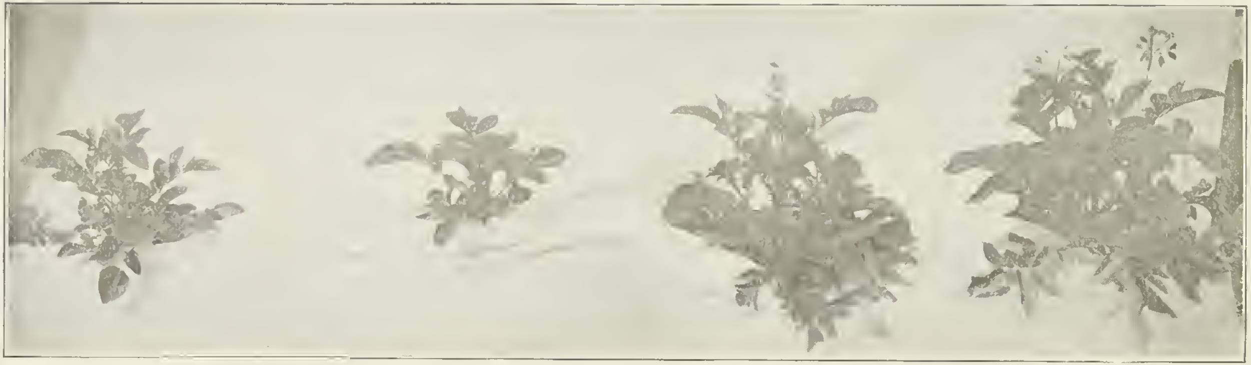

FIG. 34. Leafroll tuber unit, Green Mountain variety. with net-necrosis stem-end quarters planted at the left. Photographed July 9, 1919, in northeastern Maine. Note the smaller size and less advanced stage of the plants from the quarters affected with net-necrosis.

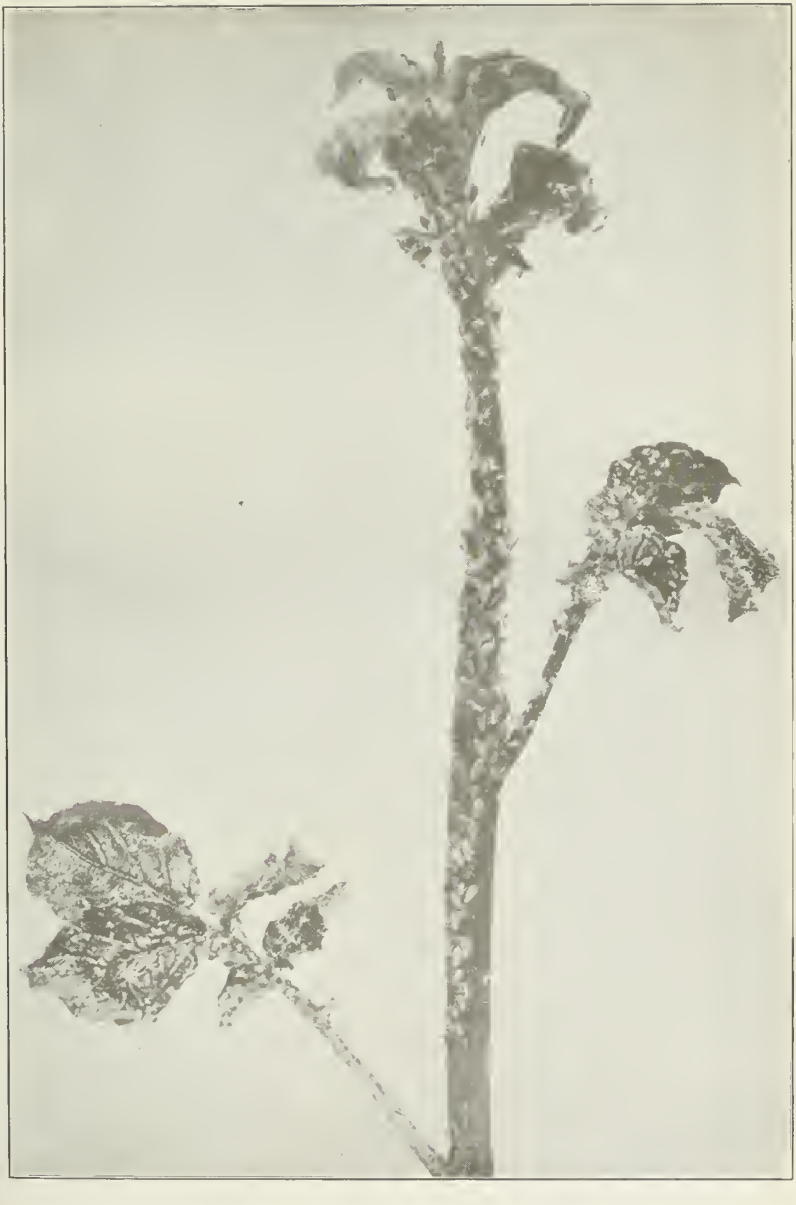

FIG. 35. Plant-lice and their shed skins upon potato stem and leaf.